

Carbon Sequestration R&D Overview



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Science & Technology Symposium**
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Technological Carbon Management Options

Reduce Carbon Intensity

- Renewables
- Nuclear
- Fuel Switching

Improve Efficiency

- Demand Side
- Supply Side

Sequester Carbon

- Capture & Store
- Enhance Natural Sinks

All options needed to:

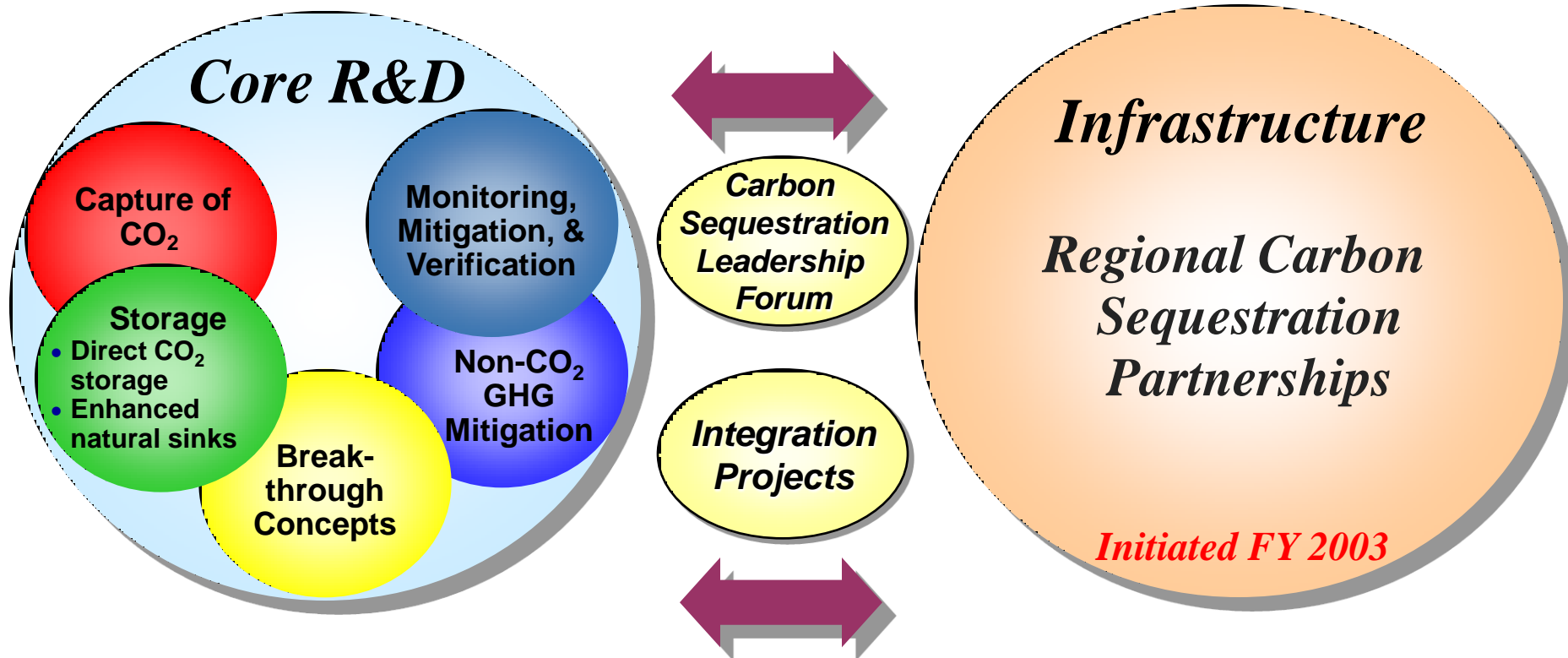
- Affordably meet energy demand
- Address environmental objectives



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DOE's Sequestration Program Structure



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Carbon Sequestration Program Goals

- **Deliver technologies & best practices that validate:**
 - 90% CO₂ capture
 - 99% storage permanence
 - <10% increase in COE (pre-combustion capture)
 - <20% increase in COE (post- and oxy-combustion)
 - +/- 30% storage capacity

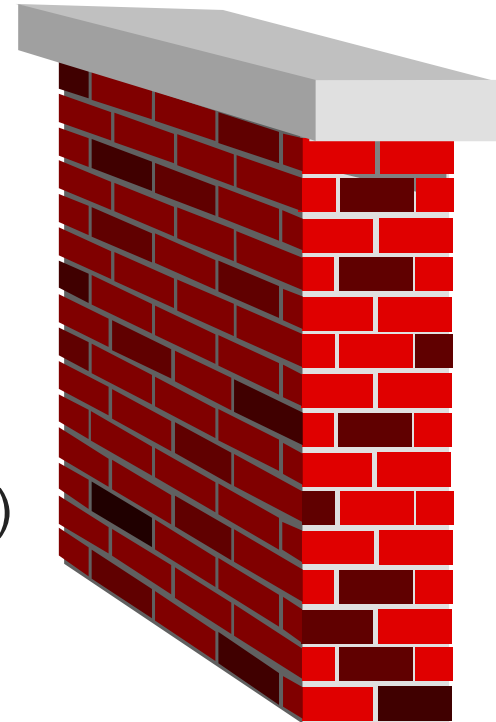


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Key Challenges to CCS

- Sufficient Storage Capacity ?
- Cost of CCS ?
- Permanence ?
- Infrastructure ?
 - Transport Lines
 - Permitting
 - Regulatory framework
 - Public Acceptance (NIMBY → NUMBY)
 - Liability
 - Best Practices
 - Human Capital Resources



Sufficient Storage Capacity ?

- **Validate Storage Capacity to +/- 30% Accuracy**



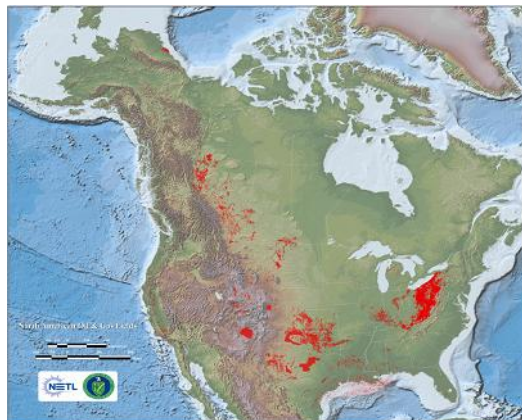
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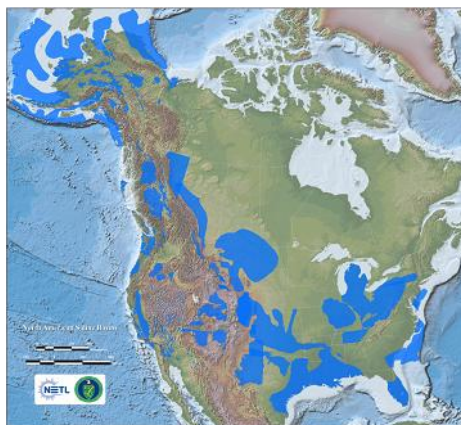
National Atlas Highlights

Adequate Storage Projected

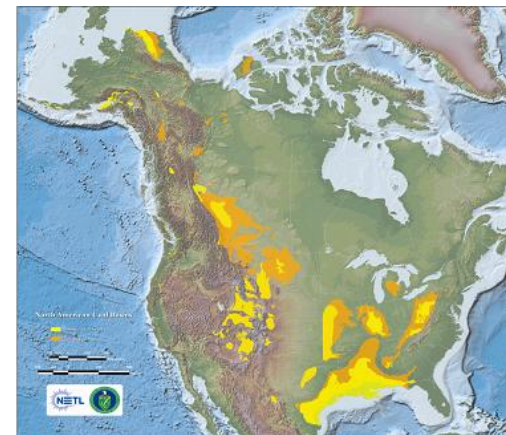
U.S. Emissions ~ 6 GT CO₂/yr all sources



Oil and Gas Fields



Saline Formations



Unmineable Coal Seams

**Conservative
Resource
Assessment**

**North American CO₂ Storage Potential
(Giga Tons)**

Sink Type	Low	High
Saline Formations	969	3,223
Unmineable Coal Seams	70	97
Oil and Gas Fields	82	83

**Hundreds of
Years of
Storage
Potential**

Available for download at http://www.netl.doe.gov/publications/carbon_seq/refshelf.html

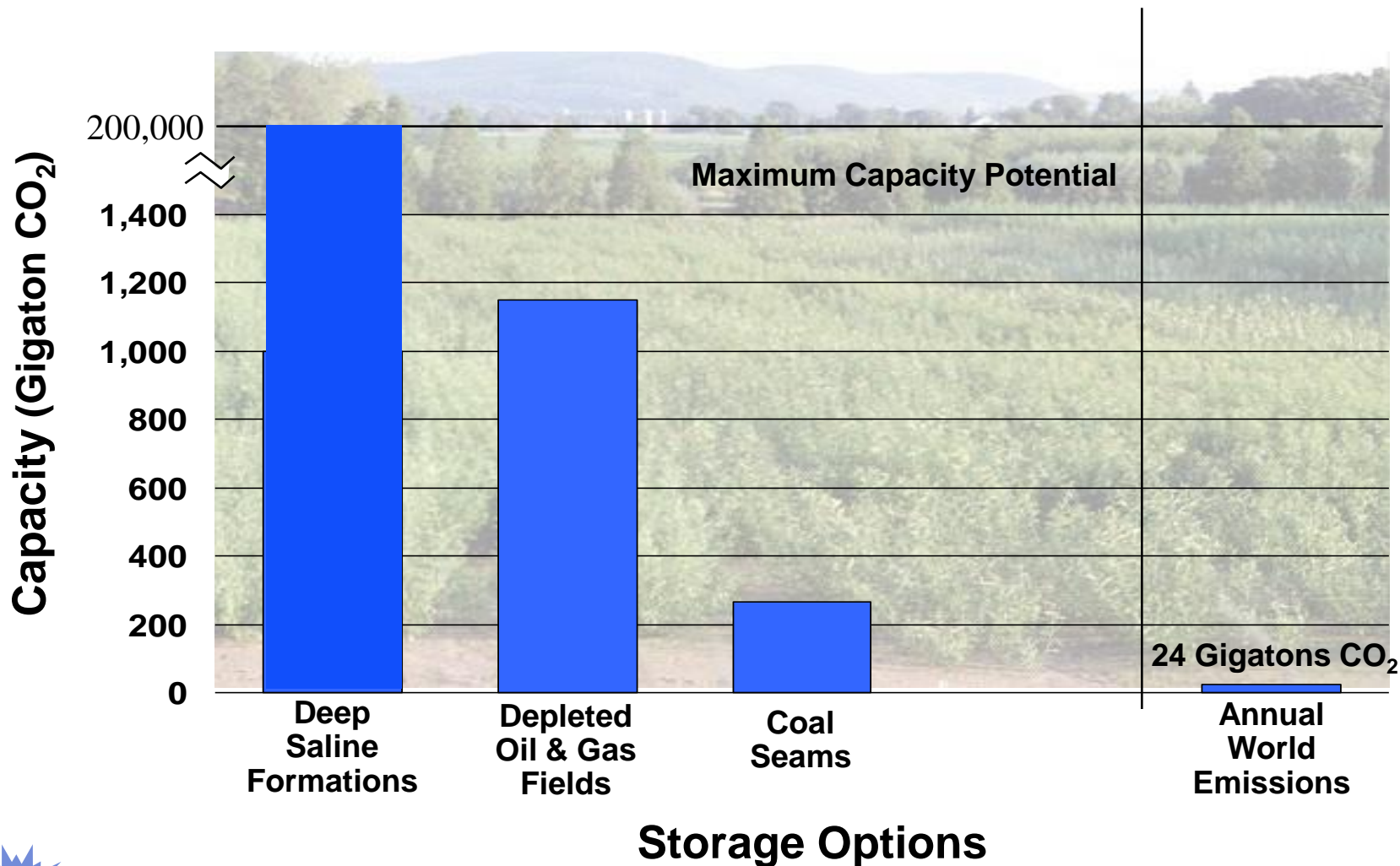


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Worldwide Geologic Storage Capacity

Thousands of Years of Potential Storage Capacity



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Storage Options:

World Emissions: DOE/EIA, International Energy Outlook 2003, Table A10

IEA Technical Review (TR4), March 2004



Cost of CCS ?

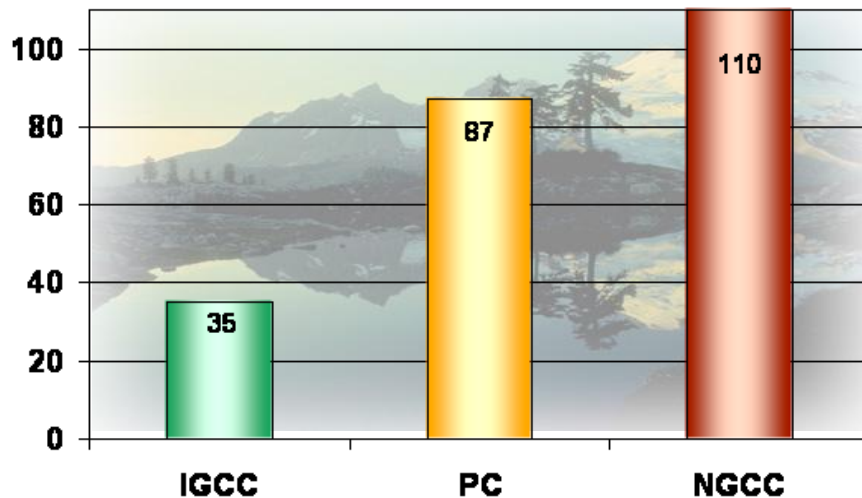
- **< 10% increase in COE (pre-combustion capture)**
- **< 20% increase in COE (post- and oxy-combustion)**



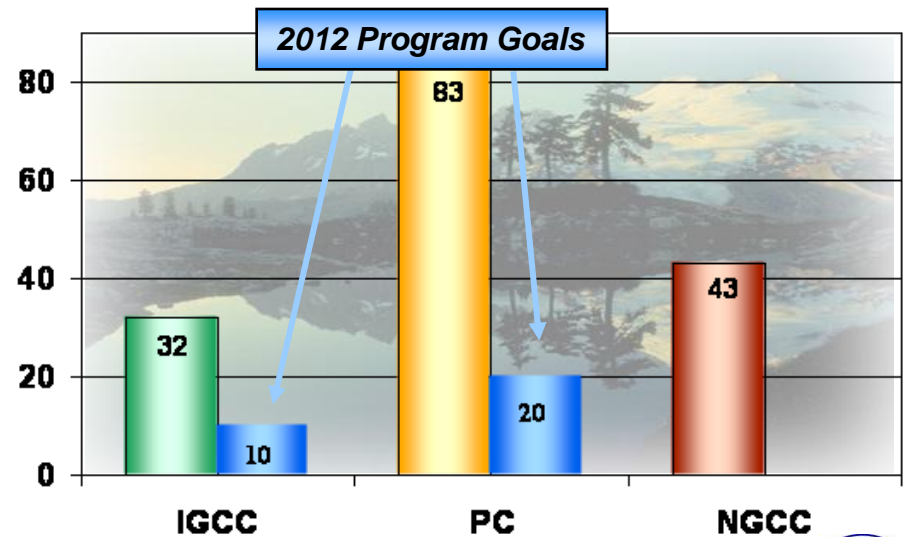
CCS Is Expensive!

- 5–30% parasitic energy loss
- 35–110% increase in capital cost
- 30–80% increase in cost of electricity

Effect of CO₂ Capture on Capital Cost
(% Increase Resulting From CO₂ Capture)



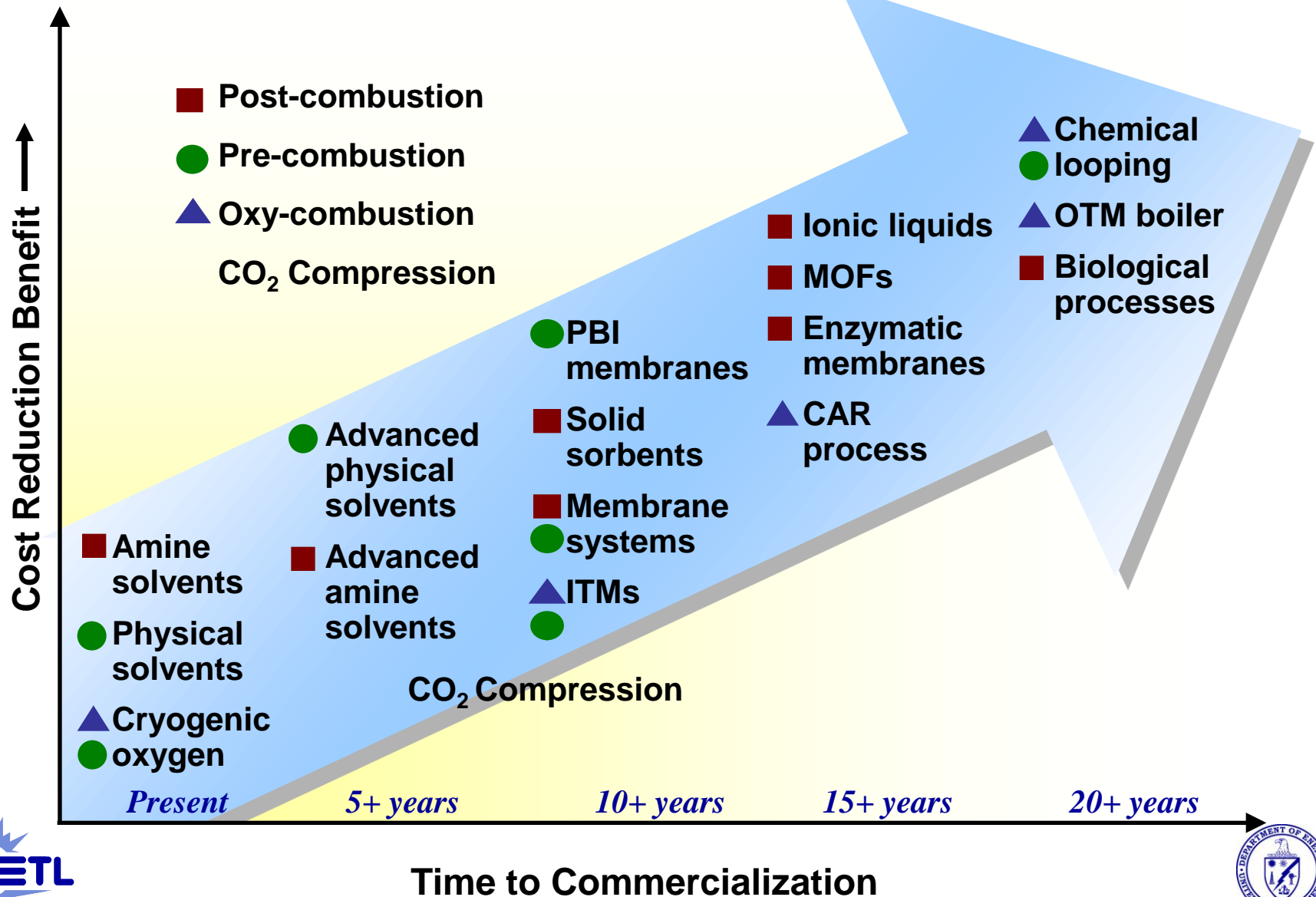
Effect of CO₂ Capture on Cost of Electricity
(% Increase Resulting From CO₂ Capture)



Source: Cost and Performance Baseline for Fossil Energy Power Plants,
Volume 1: Bituminous Coal and Natural Gas to Electricity



Technology Advances Are Starting to Emerge



Permanence ?

- **Develop tools, protocols & best practices**
- **Verify 99% storage retention**



Tools, Protocols, and Best Practices

All Risks & Leakage Pathways Are Being Studied

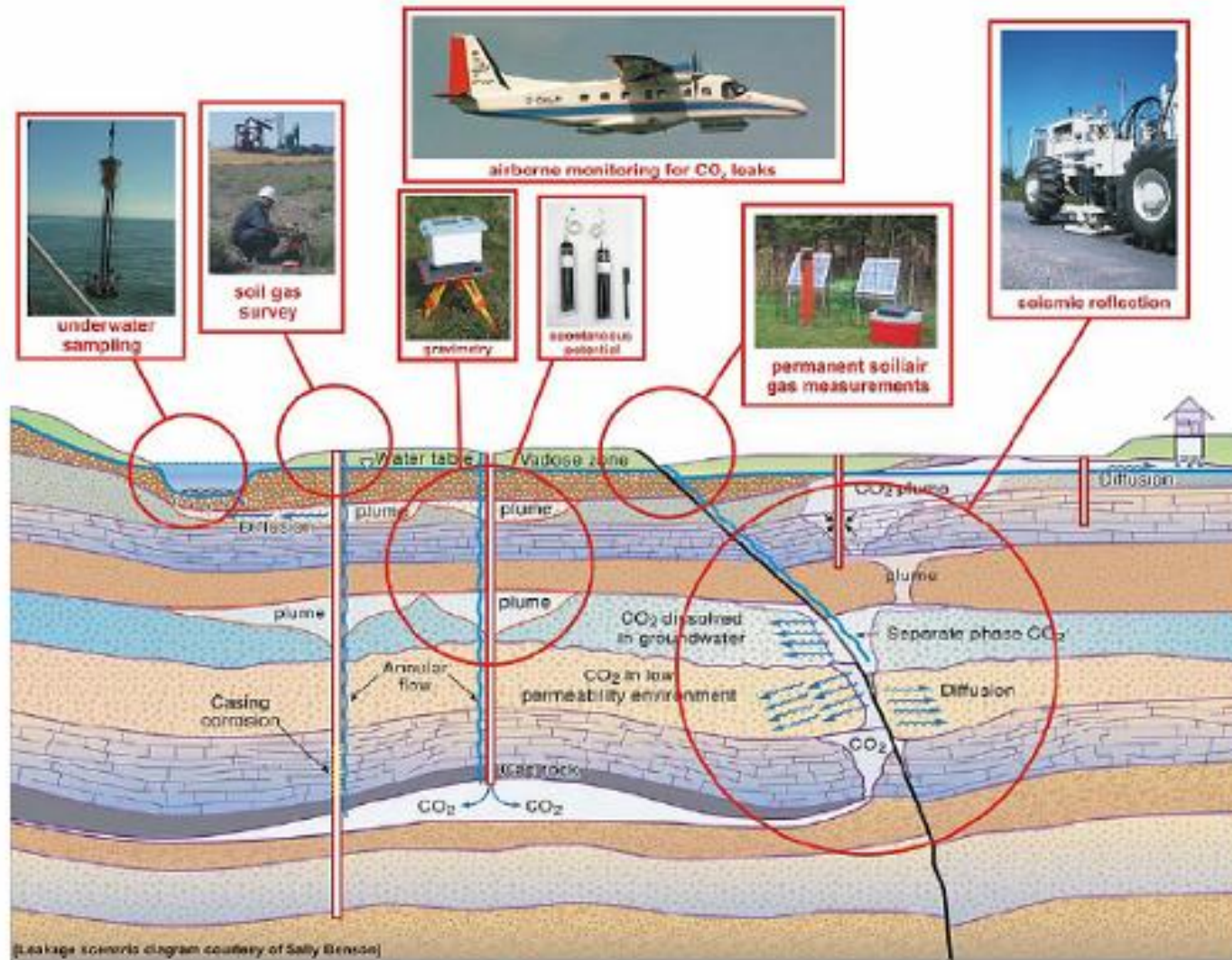
- **Environmental Risks**
 - Migration into other strata, displacement of underground fluids, ...
- **Health and Safety Risks**
 - CO₂ is a nontoxic, inert gas that displaces oxygen - asphyxiation
- **Economic Risks**
 - Liability and operational considerations, EOR commercially proven

Best Practices Manual (BMP)

- **Developing Science Protocol FY08 w/Office of Science**
 - Geologic characterization, site development and operations, risk assessment and mitigation strategies, implementation, outreach,...
- **Evolve into BMP as research continues**



Monitoring, Mitigation, and Verification Technologies & Protocols Are Emerging

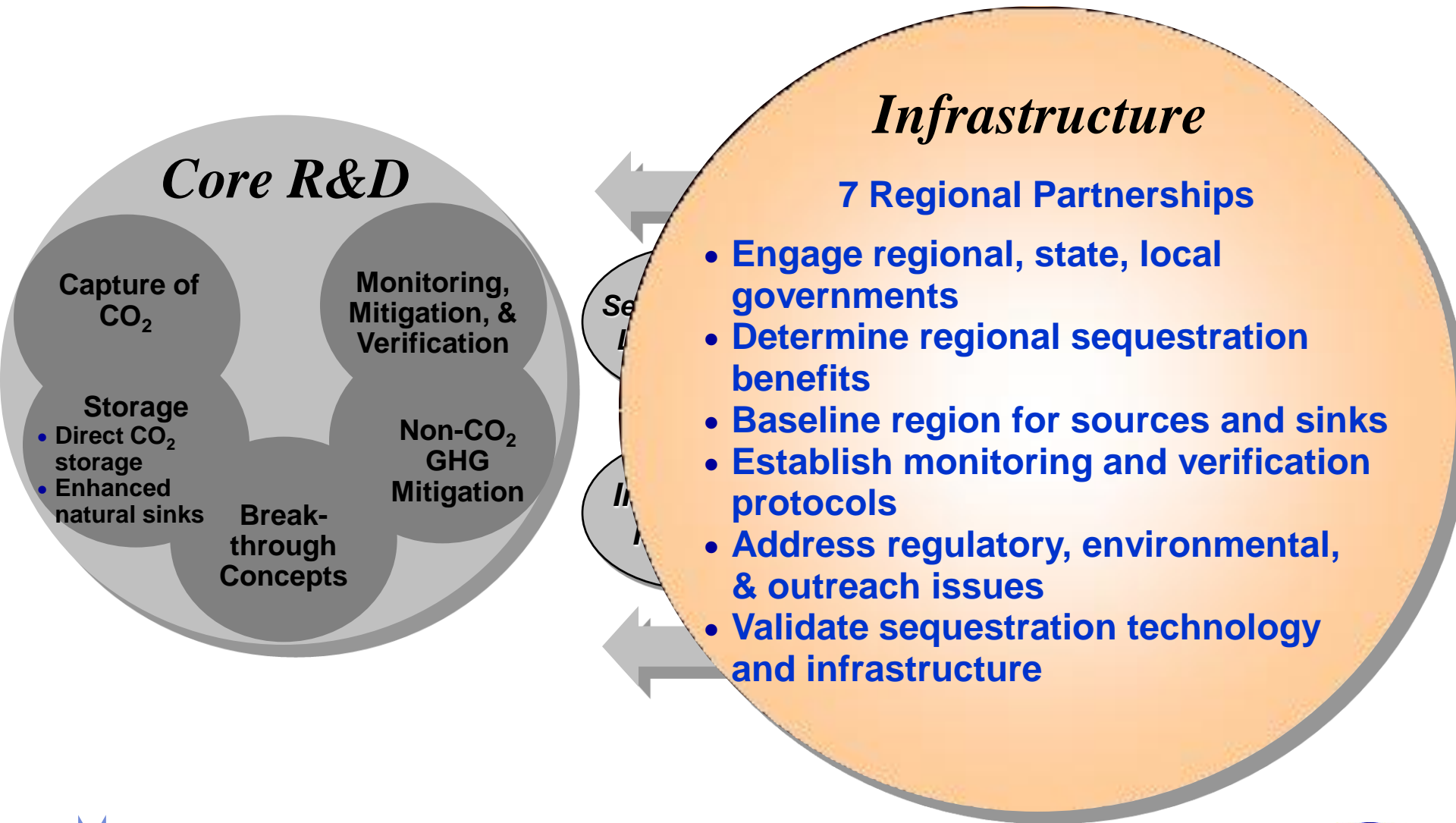


Infrastructure ?

- Put “first-of-kind” projects in place
- Develop protocols & best practices
- **Regional Carbon Sequestration Partnerships**



DOE's Sequestration Program Structure



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Regional Carbon Sequestration Partnerships

Creating Infrastructure for Wide Scale Deployment

Characterization Phase

- 24 months (2003-2005)

Validation Phase

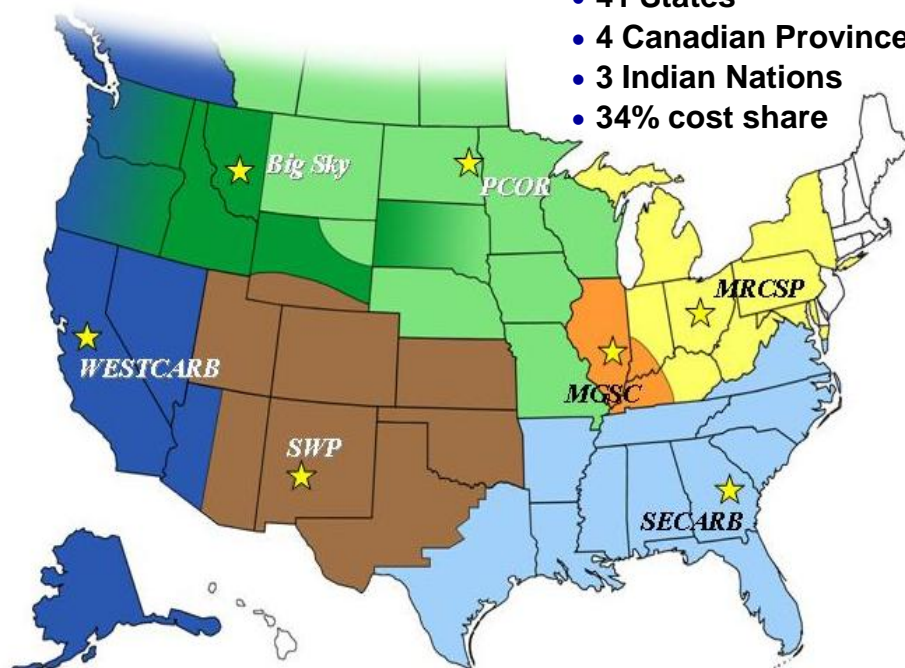
- 4 years (2005 - 2009)
- 7 Partnerships (41 states)
- 25 Geologic field validation tests

Deployment Phase

- 10 years (2008-2017)
- Several large injection tests in different geology

Representing:

- >350 Organizations
- 41 States
- 4 Canadian Provinces
- 3 Indian Nations
- 34% cost share



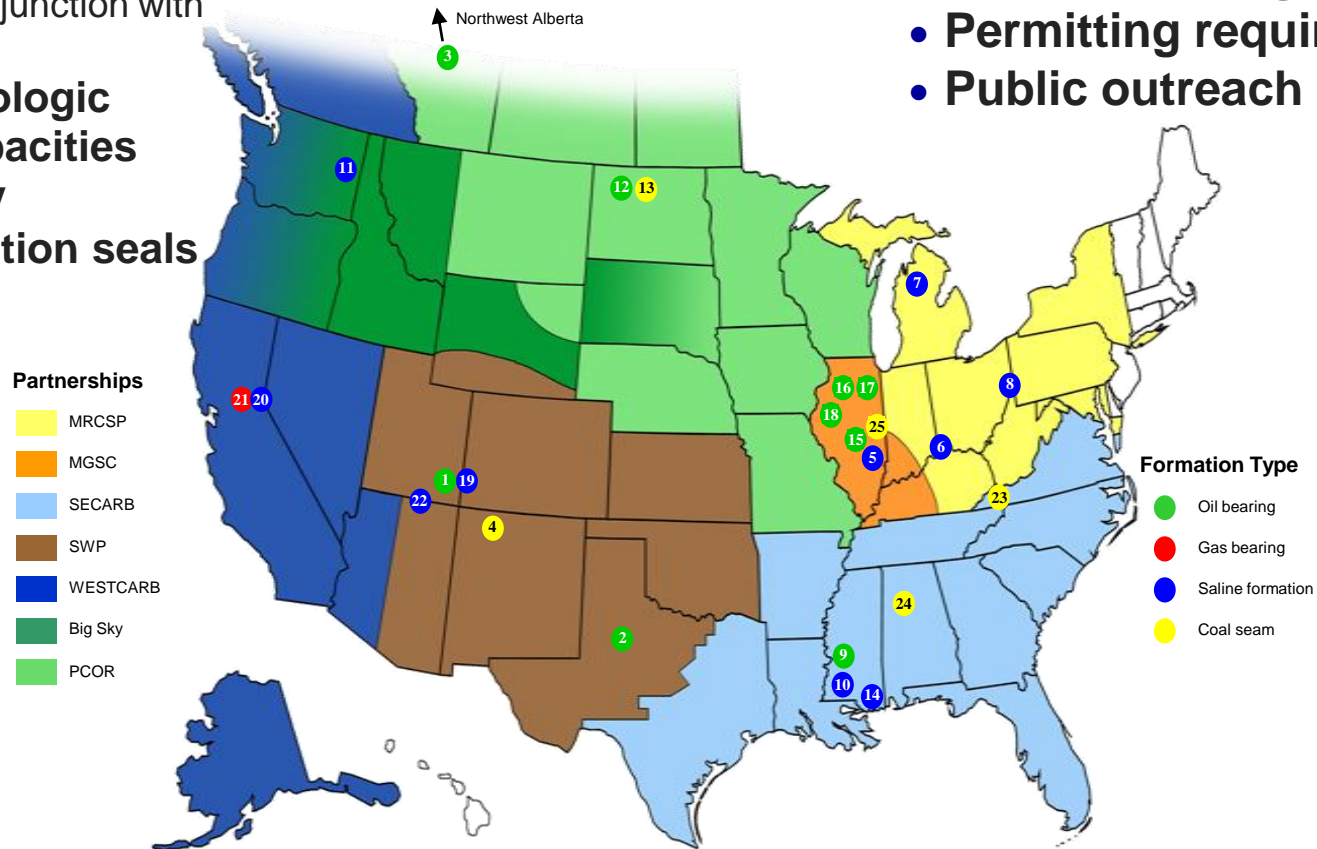
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Phase II Field Validation

25 Geologic Tests

- Injections 750-525,000 Tons CO₂
 - Larger in conjunction with EOR
- Validating geologic formation capacities and injectivity
- Testing formation seals

- MMV technologies
- Permitting requirements
- Public outreach



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**Summary of Regional Carbon Sequestration Partnerships
Phase II Field Activities – estimate as of Q2 2007**

		FY 2006				FY 2007				FY 2008				FY 2009			
Geologic Field Test		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
Big Sky	Basalt and Mafic Rock Field Validation Test																
MRCSP	Appalachian Basin Geologic Test																
	Cincinnati Arch Geologic Test																
	Michigan Basin Geologic Test																
MGSC	Saline Formation Tests																
	Enhanced Oil Recovery Tests (Huff 'n Puff)																
	Enhanced Oil Recovery Well Conversion																
	Enhanced Coalbed Methane Tests																
PCOR	Lignite in North Dakota Field Validation Test																
	Zama Field Validation Test																
	Beaver Lodge EOR Field Test																
SECARB	Gulf Coast Stacked Storage Project																
	Black Warrior Basin Coal Test																
	Central Appalachian Basin Coal Test																
	Saline Reservoir Field Test: Mississippi Test Site																
SWPCS	Paradox Basin, UT: Aneth EOR-Seq and Deep Saline Tests																
	Permian Basin, TXe SACROC-Claytonville EOR-Seq Test																
	San Juan Basin, NM: ECBM-Sequestration Test																
WESTCARB	Rosetta Resources Gas Reservoir and Saline Formation																
	Northern Arizona Saline Formation CO2 Storage Pilot																



- Baseline



- Drilling



- Injection

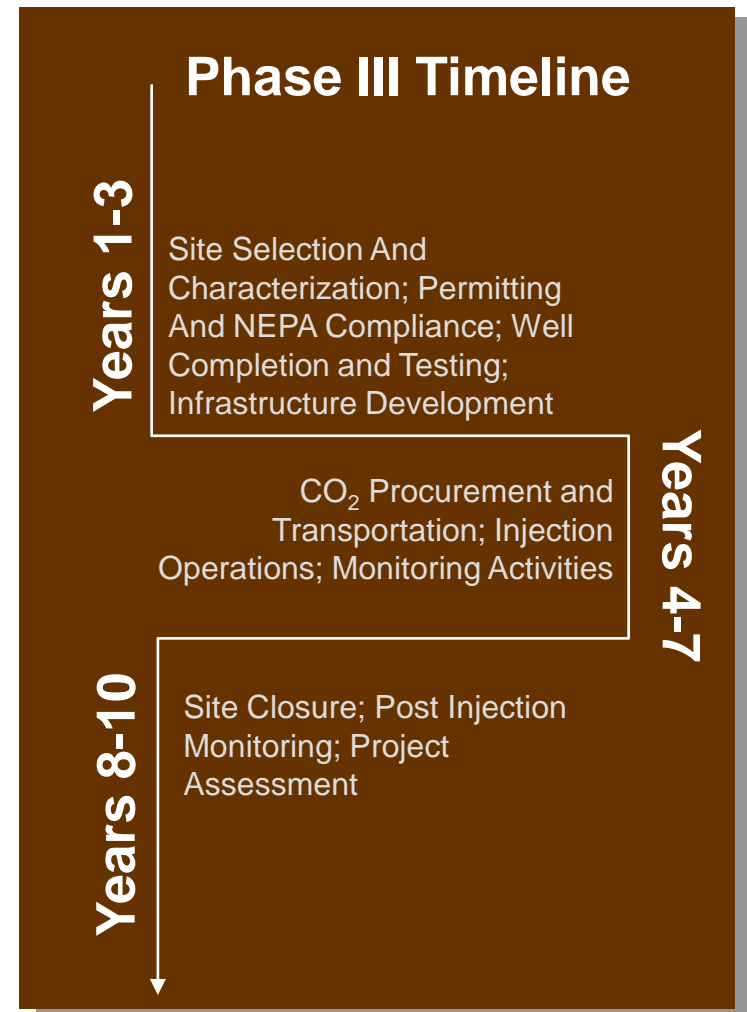


- MMV

Deployment Phase

Scaling Up Towards Commercialization

- **FY 2008-2017 (10 years)**
- **Several large-volume sequestration tests in North America**
- **Injection rates up to 1,000,000 tons per year for several years**
- **Scale up is required to provide insight into several operational and technical issues in different formations**



Large-Scale Test Locations

as of 2/8/2008

PCOR
Fort Nelson
CO₂ Acid Gas
Injection
Project

PCOR
Williston Basin CO₂
Sequestration and
EOR Test

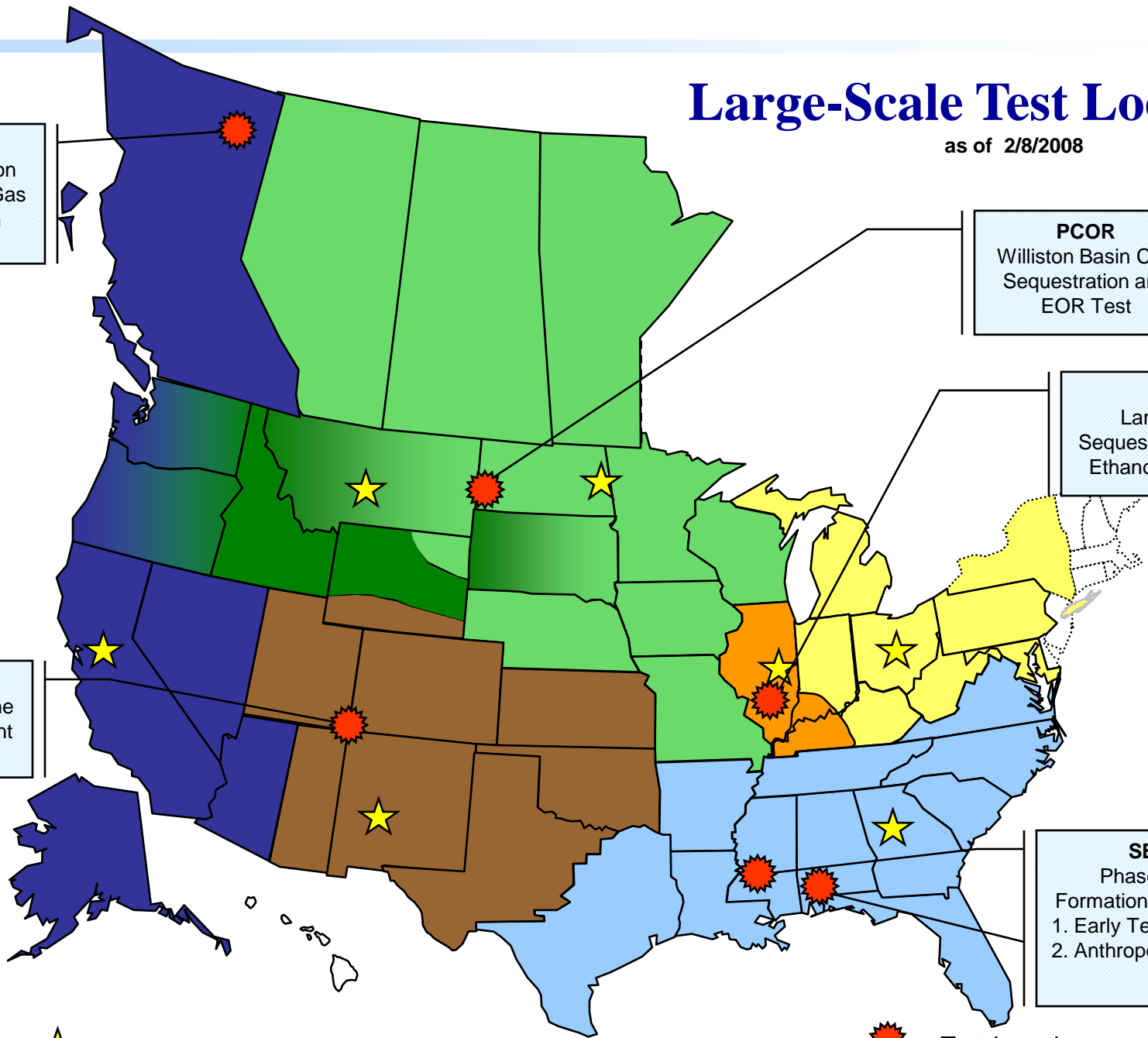
MGSC
Large-Volume
Sequestration Test with
Ethanol Plant Source

SWP
Deep Saline
Deployment
Project

SECARB
Phase III Saline
Formation Demonstration
1. Early Test
2. Anthropogenic Test

★ - Partnership Headquarters

★ - Test Location



Deployment Phase Outcomes

- **Site characterization requirements**
- **Storage capacity assessment**
- **Design criteria**
 - Injection wells
 - Regional monitoring, mitigation, and verification program
 - Site closure
- **Permitting requirements**
- **Validate reservoir and risk assessment models**
- **Accelerate public outreach**
- **Science Protocols**
- **Best practice manuals**



Carbon Sequestration Leadership Forum (CSLFF)

- CSLF charter signed on 25 June 2003 in Washington, DC
- International climate change initiative
- Facilitate development of cost-effective technologies
- Promotes technical, political, and regulatory environments to develop such technology
- Technical and Policy Committees, including Capacity Building and Financing Task Forces
- 20 approved RD&D projects



Carbon Sequestration Leadership Forum (CSLF) Membership

- Australia
- **Brazil**
- Canada
- **China**
- **Colombia**
- Denmark
- European Commission
- France
- Germany
- Greece
- **India**



- Italy
- Japan
- Republic of Korea
- **Mexico**
- Netherlands
- Norway
- Russian Federation
- Saudi Arabia
- **South Africa**
- United Kingdom
- United States



Developing Member Countries



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FOSSIL ENERGY NEWS SPOTLIGHT

DOE Selects Projects to Advance Fuel Cell Technology

The Department of Energy has announced the selection of nine projects for the Department's Solid State Energy Conversion Alliance Core Technology Program portfolio that will address specific challenges in scaling up and integrating solid oxide fuel cells into advanced central generation power plants. [Read more >](#)

MORE COAL, OIL & GAS NEWS

University Coal Research Program Begins 30th Year

The Department of Energy has released a funding opportunity announcement calling on U.S. colleges and universities to propose new projects to enhance the long-term use of coal. [Read more >](#)

DOE Will Not Enter Into Contracts for Continued SPR Fill

The Department of Energy announced it will not sign contracts this year for the receipt, exchange and transportation of up to 13 million barrels of crude oil to the Nation's strategic petroleum reserve sites. [Read more >](#)

DOE Issues Draft Solicitation for Restructured FutureGen Approach

National Energy Technology Laboratory

Site Map GO

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Tackling U.S. Energy Challenges

Secure and Reliable Energy

Domestic coal, oil, and natural gas resources can contribute enormously to our Nation's economic strength, energy security, and quality of life through the 21st century.

[View Secure & Reliable Energy Supplies](#)

NETL's Bauer Named 'Laboratory Director of the Year'

Carl Bauer, Director of the Office of Fossil Energy's National Energy Technology Laboratory, has been named a Laboratory Director of the Year by the Federal Laboratory Consortium for Technology Transfer. [Read More!](#)



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NEWS & FEATURES // All >

- President Requests \$863 Million for Fossil Energy Programs
- DOE's Microhole R&D Program Yielding Promising New Tools
- Supplement to the Draft EIS for the Gilberton Coal-to-Clean Fuels and Power Project [PDF-8MB]
- Draft EIS for the Gilberton Coal-to-Clean Fuels
- Groundwater Monitoring at NETL-Albany

EVENTS CALENDAR // All >

- Science Bowl Information
- World of Coal Ash (WOCA) 2007 Conference

PUBLICATIONS & PROJECTS // All >

- netlog newsletter
- 2005 Annual Site Environmental Report
- 2006 Mercury Control

<http://fossil.energy.gov/>

<http://www.netl.doe.gov>

